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A Wide Band Compact Size UHF Band Monopole Clustered with L and S Band Dipoles for Self-networking Communication in Handset Devices

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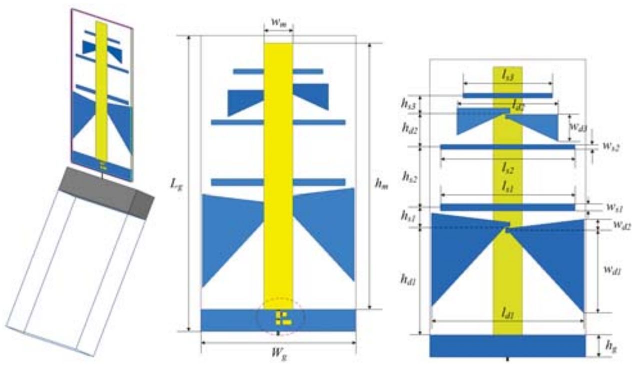
***Abstract*—A wide band monopole antenna that works at Ultrahigh frequency (UHF) clustered with two wide band dipole antennas that work at L and S band are proposed in this paper. The three antennas are in the cover of a handset device which connects to the ground plane on its main body with a wire. The UHF monopole antenna covers the frequency band from 350 MHz to 780 MHz with VSWR lower than 3 in a total length of 0.16λ_0 with omnidirectional gain upon 0 dBi which is used for self-networking communication. The L band dipole antenna shares part of the ground plane with the UHF monopole antenna, which works from 1.23 GHz to 1.62 GHz, with the end fire gain upon 6 dBi. The S band dipole antenna covers from 1.7 GHz to 2.34 GHz with gain upon 6 dBi. The three antennas have good isolation higher than 15 dB. The simulation indicates that the proposed clustered antennas have small volume, stable radiation pattern and wide band.**

***Index Terms*—clustered antenna, UHF, wide band antennas.**

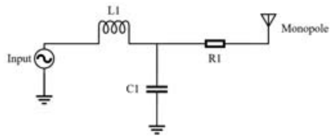
I. Introduction

Ultrahigh frequency (UHF) band is used in a lot of applications, including radar, digital audio/video broadcasting, UHF radio-frequency identification tags and so on [1]. The frequency band from 400 MHz to 680 MHz has also been utilized in the field of self-networking communication. Since the environment for self-networking communication has no base station covering, the gain of the antenna should not be too low. Omni-directional radiation pattern is also required for detecting team members from all the directions. Since the antenna size is bigger as the frequency operated going lower. To integrate the UHF antenna into a handset device, compact size and light weight is also considered in the antenna design. In previous researching, meander line and spiral-shaped antennas have been proposed to get compact size to adapt to different applications [2] and [3]. In [2], the antenna has two narrow working band 315 MHz and 433 MHz with low profile and small volume. But it relies on a big enough metal ground and its gain is still as low as -10 dBi. In [3], the antenna gain is reasonable as 1.8 dBi at 795 MHz with a total length of 0.22λ_0, but it has narrow bandwidth. [4] proposed an ultra-wide band cavity- backed bowtie antenna that works at UHF band with relative band width of 108.5%. [5] proposed a log periodic fractal Koch antenna which has relative bandwidth upon 200% and gain above 7 dBi with low profile structure. But both [4] and [5] has large antenna size and end fire radiation pattern. In [6], a monopole antenna with one end grounded is proposed with total length of 0.25λ_0 and omnidirectional gain upon 0 dBi, but its working band is still not wide enough.

In this paper, a wide band UHF monopole antenna clustered with L and S band dipole antennas are proposed with low profile, compact size and higher than 0 dBi gain. All antennas are in the cover of a handset device which is used for self-networking communication. The paper is organized as follow: section II describes a brief antenna design foundation. Section III discusses simulation results and discussing, conclusions and references are described is section IV.



(a) Antennas in the handset device (b) Front side of the antenna layer (c) Back side of the antenna layer



(d) Matching circuits of monopole antenna

Fig. 1: Antenna configuration

II. Antenna Design

A simple structure of the handset device is shown in Fig. 1(a). All the antenna structures are printed on FR4 substrate with r = 4.4 and thickness 0.8 mm which is integrated with the cover. The monopole antenna is on the front side of the substrate as shown in Fig. 1(b). The part inside the dash line circle is the matching circuit and feeding point. The matching circuit is shown in Fig. 1(d). The ground of the monopole antenna can be divided into two parts: one is the bottom strip on the back side of the substrate; the

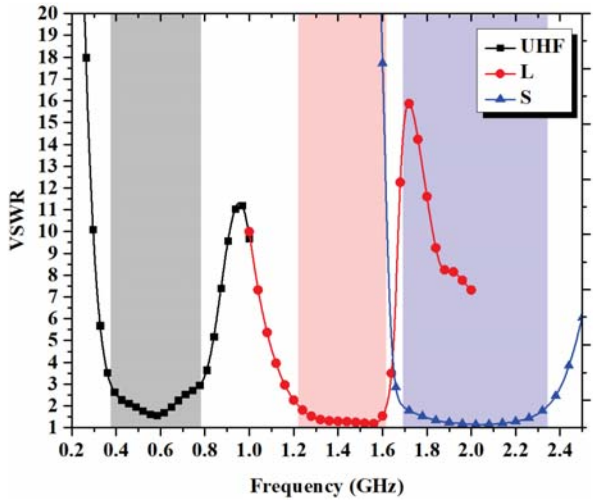


Fig. 2: 2 VSWR of the UHF, L and S band antenna

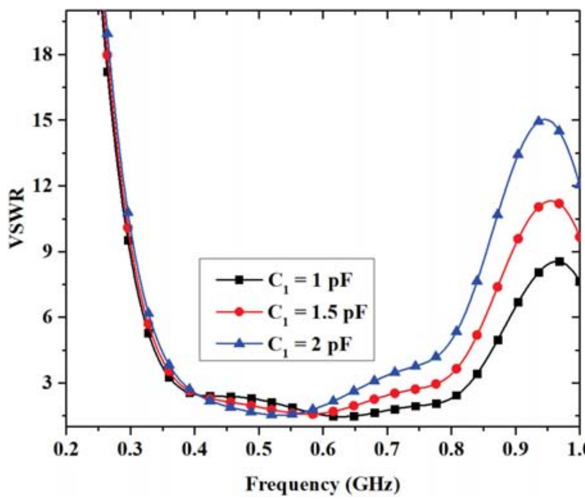
TABLE I: Antenna Structure Dimensions

W_g	69.5	L_g	133.5	h_m	120	w_m	13	h_g	10
l_{d1}	68	h_{d1}	47.2	w_{d1}	37	w_{d2}	5	h_{s1}	9
w_{s1}	3	l_{s1}	60	h_{s2}	27	l_{s2}	60	w_{s2}	2
h_{d2}	15	w_{d3}	12	l_{d2}	45	h_{s3}	8	l_{s3}	40

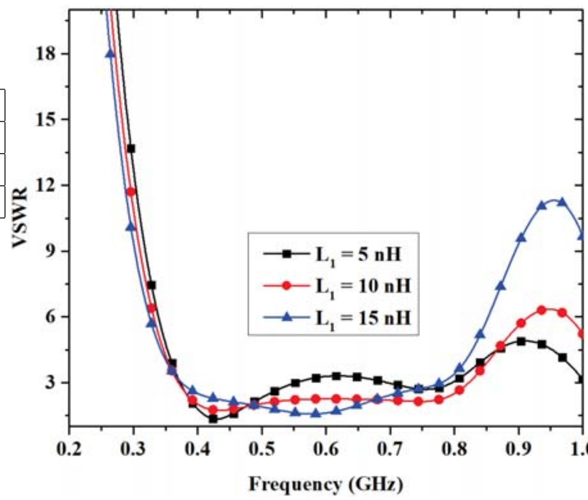
other one is the main body which relates to the bottom strip by a wire. The main body length is 155 mm. The two dipole antennas are on the back side of the substrate as shown in Fig. 1(c). The lower dipole antenna works at L band while the upper one works at S band. Both dipoles are in bow-tie shape for extending their working band. The dipole antennas are fed by coaxial cables in the center. The two arms are in different height for easy feeding. The strips upon the bow-tie structures introduce capacitance coupling between the two arms and improve their impedance matching. For the lower dipole, the strip on the bottom works as its reflector as well as part of the ground of the monopole antenna. For the upper dipole, the strip below the bow-tie structure is introduced as a reflector. Since the S band dipole antenna is smaller than the L band dipole, the radiation of the lower dipole antenna will not be reflected by the higher one. The dipole antennas have horizontal polarization, while the monopole antenna has vertical polarization. Therefore, the monopole antenna has high isolation with both dipole antennas. The antenna structure dimensions are shown in Table I.

III. Simulation and Discussion

In this section, the antennas are designed and simulated in HFSS. Fig. 2 shows simulation results of VSWR. Acceptable VSWR below 3 is obtained for the monopole antenna from 380 MHz to 780 MHz. For the L band dipole antenna is from 1.23 GHz to 1.62 GHz and for S band dipole antenna is from 1.7 GHz to 2.34 GHz below 2. Fig. 3 shows the influence of the inductor and capacitor in matching network of the monopole antenna. As shown in Fig. 3(a), when L1 is 15 nH and C1 changes from 1 pF to 2 pF, the band width decreases especially in the higher band, while the impedance matching from 400 MHz to 600 MHz becomes better. If the capacitance is fixed as



(a) Fixed L1 with different C1



(b) Fixed C1 with different L1

Fig. 3: VSWR of different inductance and capacitance

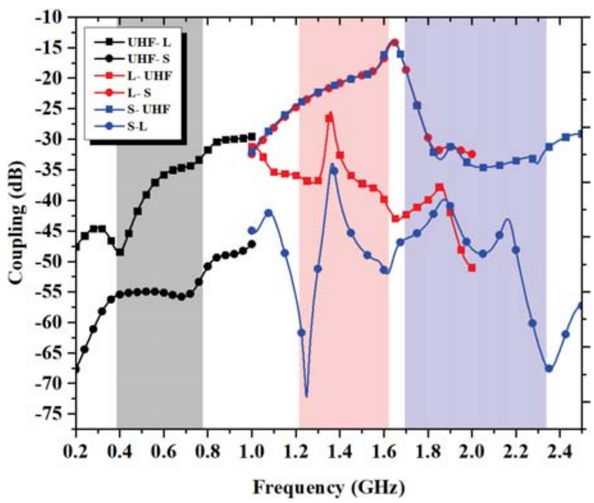


Fig. 4: Coupling between the three antennas

1.5 pF and change the inductance from 5 nH to 15 nH, as shown in Fig. 3(b), the impedance matching from 490 MHz to 670 MHz becomes better. Even though the band width reaches a maximum when L1 = 10 nH, the result of L1 = 15 nH is chosen because it has the best impedance matching in the working band from 400 to 700 MHz for the self-networking system. Fig. 4 shows the coupling between the three antennas. The coupling in UHF band and S band is almost below -30 dB. In L band, the coupling between L and S band antenna is below -15 dB. Fig. 5(a) and Fig. 5(b) is the radiation pattern of the UHF band antenna at 400 MHz and 680 MHz with realized gain 2.94 dBi and 1.92 dBi, respectively. The gain looks higher in the lower band because the radiation pattern is less symmetric in this band. In this simulation model, the ground plane of the main body is not parallel with the antenna plane, which has higher influence on the lower band radiation pattern. Fig. 5(c) is the E-plane and H-plane radiation pattern of L band antenna with the gain of 6.29 dBi. Fig. 5(d) is the E-plane and H-plane radiation pattern of S band antenna with the gain of 6.76 dBi.

IV. Conclusion

Three clustered antennas for self-networking communication is proposed in this paper. The three antennas are working at UHF, L and S band with bandwidth of 76.1%, 27.4% and 31.7%, respectively. The UHF antenna has omni-directional radiation pattern and vertical polarization. The L and S band antenna has endfire radiation pattern and horizontal polarization. Since the orthogonal polarization, the L and S band antennas have high isolation with the UHF band antenna. The simulation shows the antennas have good performance with low profile and compact size.

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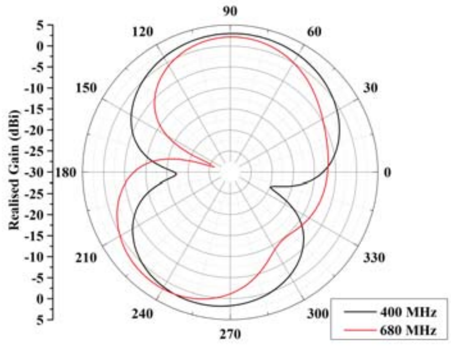
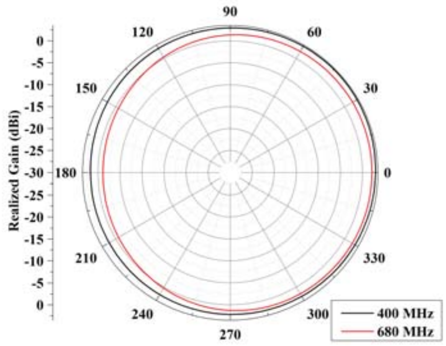
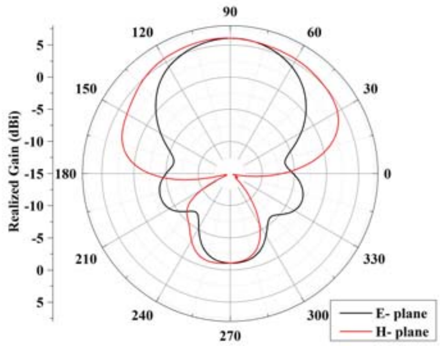


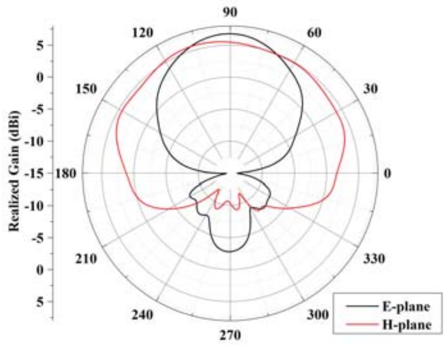
(a) E-plane radiation pattern of UHF antenna at 400 MHz and 680 MHz



(b) H-plane radiation pattern of UHF antenna at 400 MHz and 680 MHz



(c) E-plane and H-plane radiation pattern of L band antenna



(d) E-plane and H-plane radiation pattern of S band antenna

Fig. 5: Radiation patterns